Readability of Maps on Mobile Phones

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Abstract:

In the present study, we attempt to estimate the readability of maps displayed on mobile phones, focusing on the process of identifying the destination based on clues that comprise the geographical information around the destination. The present paper develops a calculation method for the load associated with searching for clues by reading maps on mobile phones. As a case study, the proposed method is applied to the spatial relation between destination restaurants around Shinjuku station and clues for identifying their locations. First, maps around Shinjuku station are searched using PCs. Recognizable buildings on large-scale or small-scale maps are obtained, and clues for identifying the destination on each map are categorized. Second, maps around Shinjuku station are searched using a mobile phone. Finally, focusing on the process of identifying the location of destination restaurants in Shinjuku by reading maps displayed on mobile phones, the load associated with searching for clues around the destination restaurants is formulated.

1. INTRODUCTION

Recent technical innovations in mobile phones have been brought about by the rapid development of information and communications technology. It is now possible to connect to and access various sites on the Internet using mobile phones, regardless of user location, to obtain desired information. Maps and other local information are examples of useful information that can be accessed from mobile phones. Reading maps on a mobile phone is a very convenient way to obtain locality information away from home or workplace.

Due to the small size of mobile phone displays, however, reading maps on mobile phones can be inconvenient and frustrating compared to reading maps on PC displays, which have much larger screens. This is partly because digital maps displayed on mobile phones were originally developed for reading on PC displays. In addition, the display range of mobile phones is often too small to view complete map images. Therefore, some images may be split into parts. If the scale is relatively large, only partial images of large buildings are displayed. Even when large-scale maps can be displayed, it is often not possible to identify locations due to the absence of the entire image of the building that contains the destination. However, when the scale size is smaller, complete images of small buildings are displayed alongside neighboring buildings. The spatial relationship between a building that contains the destination and other neighboring buildings may then help to identify a destination on a mobile phone map, despite the small size of the map image.

In the present study, by considering the relationship among the displayed image, the display range, and the process of identifying a destination, we investigate new ways to improve the usability of reading maps on mobile phones with functions similar to PCs.

2. RESEARCH METHOD

The present study considers the identification of the destination by reading maps on mobile phones. Reaching a destination requires the identification of its location. In addition, it is necessary to obtain the spatial relationship between the destination and geographical information around the destination in order to identify its location. For example, pedestrian navigation by mobile phone provides sequential directions starting from an actual location and ending at the destination. We can identify the destination correctly and reach the destination directly. In consideration of the small displays of mobile phones, maps for pedestrian navigation are often deformed. In a previous study related to the route guide and deformed map, Fujii et al. (2000) described a system to generate route guide maps for mobile terminals. Ninomiya et al. (2006) proposed effective deformed maps for mobile devices with a small display. Kakuchi et al. (2002) developed a method to evaluate the advantage of position based on route information. Furthermore, in connection with the deformed maps, the relationship between display scale and display object is extensively studied (e.g., Teraki 2000, Kano et al. 2003, 2004; Ota et al. 2005).

Meanwhile, without sequential support by a route guide system, we can reach a destination on the basis of the geographical information around destination, such as landmarks, and can identify the destinations on maps. For example, Nihon Computer Graphic[1] developed a generation system for deformed maps that chooses important geographical information within the region containing the destination and present location. However, this system does not consider the effect of information seeking behavior on mobile phones. We can search for geographical information around the destination by reading a map on a mobile phone by scrolling the viewing area of the map. As a previous study related to information seeking behavior, Yanagisawa and Yoshikawa (2005) formulated routes and load associated with quest for shops based on visual information in urban space. In addition, the intervening opportunity model (Stouffer 1940, 1960; Okabe 1976) considers the relationship between the information seeking behavior and the choice of destination.
However, whether information seeking behavior can be formulated when we identify the destination by reading maps on mobile phones remains unclear. In addition, it is unclear how the process of identifying the destination will be affected by geographical information around the destination. These questions are important in considering the readability of maps on mobile phones. Therefore, in the present study, we attempt to estimate the readability of maps on mobile phones, focusing on the process of identifying the destination on the basis of clues that are the geographical information around destination. The present paper describes the development of a method of calculating the load associated with searching for clues by reading maps on mobile phones. As a case study, this method is applied to the spatial relationship between destination restaurants around Shinjuku station and clues for identifying their locations. First, maps around Shinjuku station are searched using PCs. In addition, recognizable buildings on large-scale or small-scale map are obtained and clues for identifying the destination on each scale map are categorized. Second, maps around Shinjuku station are searched using mobile phones. Finally, with a focus on the process of identifying the location of destination restaurants in Shinjuku by reading maps on mobile phones, the load associated with searching for clues around the restaurants is formulated.

3. RECOGNIZABLE BUILDINGS ON MAPS WITH SCALES OF 1/8,000 OR 1/1,500

The research objective map of the present study is supplied by the map service of Yahoo! Japan[2], which is one of the Japanese largest portal sites. In he present study, the maps are read using a PC having a display resolution of 1,280 × 1,024 pixels in order to categorize recognizable buildings. The objective region is the area around Shinjuku station that can be read on a scale of 1/1,500. Even though the size of the displayed images changes due to the display resolution, the maps read by PC can be read using mobile phones, despite the decrease in the visible area. Figure 1 shows recognizable buildings that are extracted from the map display supplied by the map service of Yahoo! Japan. In the figure, buildings displayed on maps served by Yahoo! Japan, which adopt the following two conditions, are considered to be recognizable buildings, (A) buildings that are brightly colored and highly visible, as compared with other buildings, and (B) buildings that have a clearly visible name. The recognizable buildings are important clues for identifying destinations on maps. Figure 1 was originally constructed from a cartographic database using GIS[3]. The shaded buildings in Figure 1-1 indicate recognizable buildings at a scale of 1/8,000. Similarly, the shaded buildings in Figure 1-2 indicate recognizable buildings at a scale of 1/1,500.
In the present paper, polygon-like features that are recognizable buildings and destination buildings are represented by their centroids. In Figures 1-1 and 1-2, centroids of recognizable buildings are shown. In addition, Figures 1-1 and 1-2 contain the centroid of the destination restaurant, for which information is retrievable by the map service of Yahoo! Japan.
The total number of recognizable buildings at scales of 1/8,000 and 1/1,500 are 43 and 121, respectively. The number of restaurants is 205. Figure 2 shows the frequency distribution of the rooftop area of these three building groups. Figures 1 and 2 show that the number of recognizable buildings is

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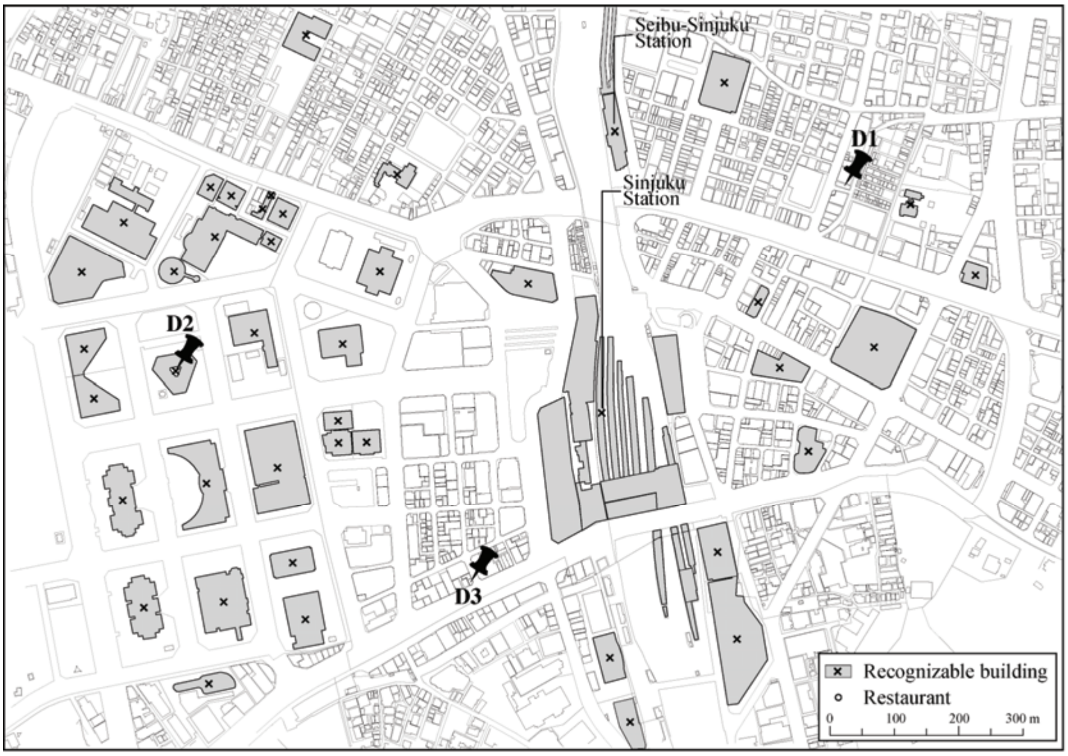
[1] Nihon Computer Graphic Co., Ltd. "Generation system of deformed map for direction" Patent No. 2001-215871, Industrial Property Digital Library, Japan Patent Office

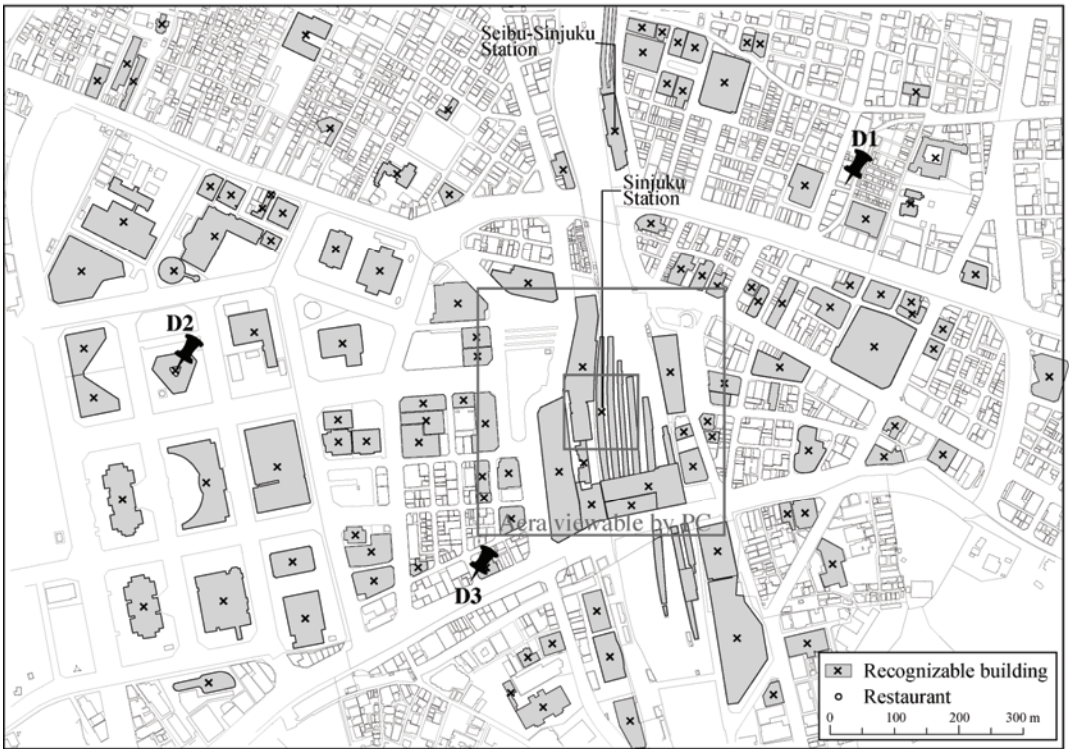
[2] Yahoo! Japan http://www.yahoo.co.jp

[3] Tokyo Metropolitan Government City Planning GIS

greater on a large-scale map than on a small-scale map. In addition, smaller buildings are recognizable on a large-scale map. Since the keyword “Shinjuku Station” indicates a huge building complex that includes rail stations and a commercial complex that encompasses the rail station, part of the rail station of Shinjuku Station is observable at a scale of 1/8,000. However, at a scale of 1/1,500, individual components of the commercial complex are recognizable.

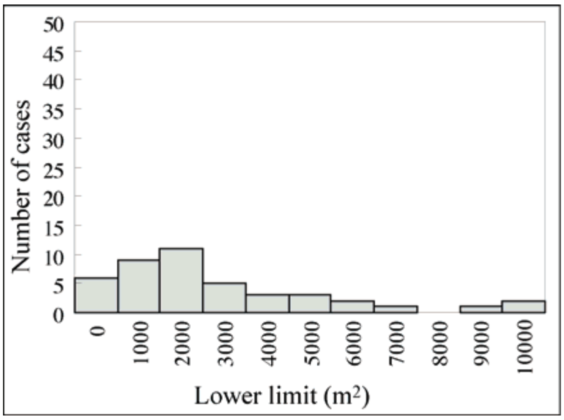


1-1. 1/8,000 scale

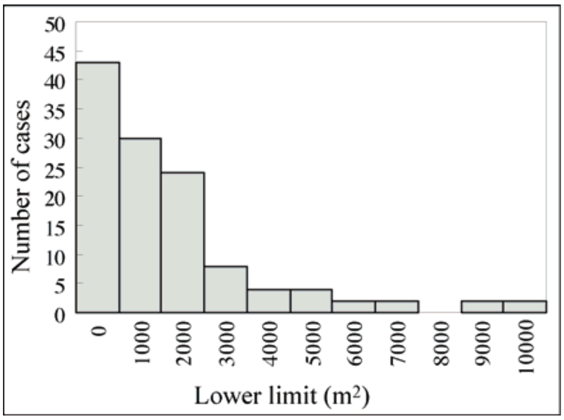


1-2. 1/1,500 scale

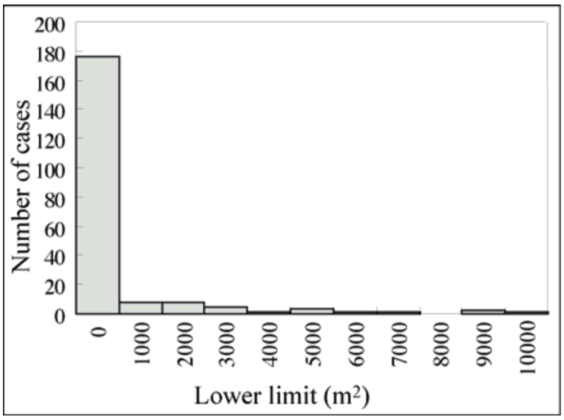
Figure 1. Recognizable buildings and restaurants



2-1. Recognizable buildings, 1/8,000 scale



2-2. Recognizable buildings, 1/1,500 scale



2-3. Restaurants

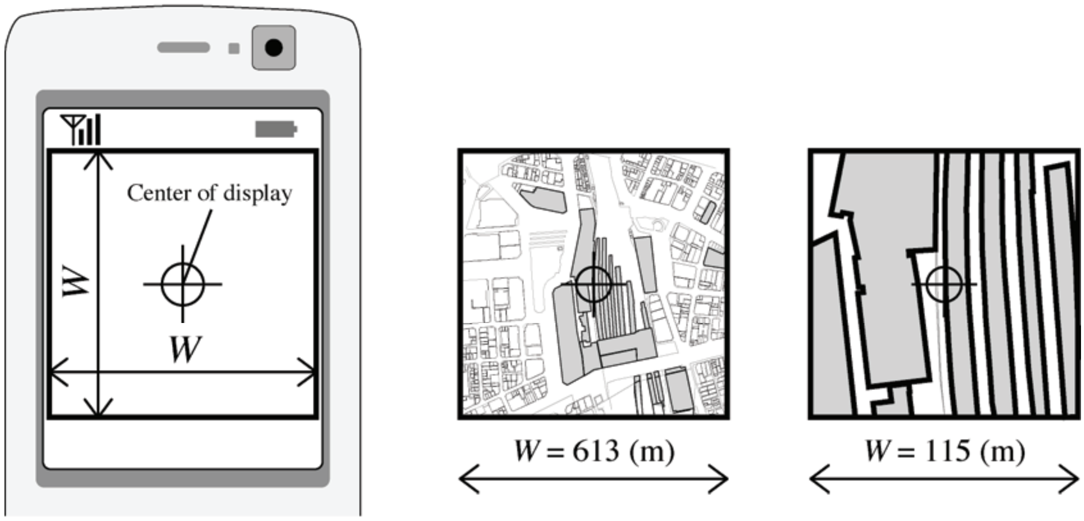
Figure 2. Frequency distribution chart of rooftop area of recognizable buildings and restaurants

4. MAP DISPLAY BY MOBILE PHONE

As a case study, the present study considers maps displayed on the SoftBank 705P[4] (Matsushita Electric Industrial Co.) mobile phone. Maps for mobile phones supplied by Yahoo! Japan are based on the same cartographic database as maps for PCs. However, the viewable area of maps for mobile phones is very small. Figure 3 shows the results of a search by mobile phone using the keyword "Shinjuku Station". The mobile phone has a 2.2-inch LCD display, the resolution of which is 320 ×

4 http://panasonic.jp/mobile/705p/

240 pixels. The viewable area at a scale of 1/8,000 is a 613 × 613 m^2 area (Figure 3-2), and the viewable area at a scale of 1/1,500 is a 115 × 115 m^2 area (Figure 3-3).



3-1. Exact size of the mobile phone used in the present study

3-2. Displayed area at 1/8,000 scale

3-3. Displayed area at 1/1,500 scale

Figure 3. Result of the search "Shinjuku Station" using the SoftBank 705P mobile phone

5. FORMULATION OF LOAD ASSOCIATED WITH SEARCHING FOR CLUES BY READING MAPS ON MOBILE PHONES

In order to formulate the load associated with searching for clues, let us analyze the process of identifying the locations of destination restaurants in Shinjuku by reading maps on mobile phone. As an example, let us assume that target restaurants are D1, D2, and D3 in Figure 1, and that their locations are identified on the basis of clues that are recognizable buildings near the target restaurants. In the present paper, the process of identifying the location of a destination restaurant is considered as follows. First, we retrieve the destination restaurant using a mobile Internet map service. As a result of retrieval, the location of the destination restaurant is shown of the map on a mobile phone. Second, by scrolling the viewing area of the map, we start to search for clues. Clues that indicate which location is closer to the destination are more helpful in identifying the precise location of the destination than clues that indicate which location is farther from the destination. With respect to reading maps on mobile phones, if a clue is located near the destination, we can search for the clue in a small range by scrolling the viewing area of the map. However, if there are no clues near the destination, we have to continue to scroll the viewing area of the map until a clue appears. In addition, the present study assumes that if one clue is obtained, then more clues will eventually be obtained. This is because an increase in the number of clues is helpful for accurately identifying the location of the destination. Finally, we will identify the destination based on the spatial relationship between clue and destination. Therefore, as a process for identifying the location of the destination, the present paper assumes that we search for clues continuously from the clue that is nearest the destination to the clue that is farthest from destination (Figure 4). The assumption of this counting method is similar to that of Cross K-function Analysis (e.g., Okabe and Yoshikawa 2003).

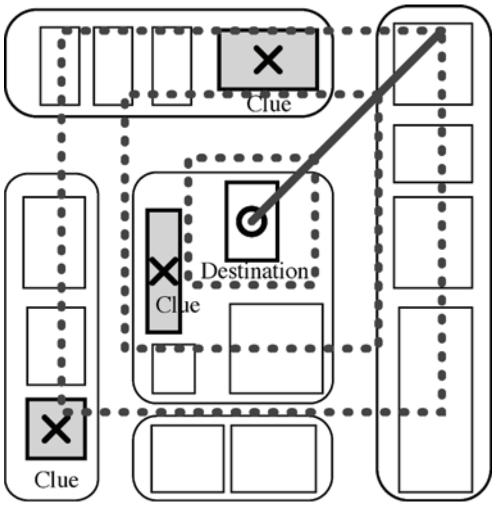


Figure 4. Process of searching for clues near the destination

Based on the assumption mentioned above, we formulate the load associated with searching for a clue near the destination (Figure 5). In the figure, *Di* denotes the destination, and *Cj* denotes the clue. Let us calculate the distance between *Di* and *Cj*. The absolute value of the difference in *x* coordinates between *Di* and *Cj* is termed *mx*. Similarly, we calculate the absolute value, termed *my*, of the difference in *y* coordinates between *Di* and *Cj*. In addition, *R* denotes the major value of either *mx* or *my*. In order to search for *Cj*, we must read in its entirety a map that includes *Di* and *Cj*, the area of which is a large square area having sides of $2R+W$ m. However, the map range that can be read using a mobile phone is limited to a $W \times W$ m^2 square area (Figure 3), where *W* denotes one side of the square viewable area of a mobile phone. Consequently, a large square area having sides of $2R+W$ m must be filled with limited square area *W* meter on a side in order to search for *Cj*. Based on this assumption, the load associated with searching for *Cj* is calculated as $(2R+W)^2/W^2$. The calculated load may be considered as the number of times that the viewing area of map must be scrolled. This load is based on the worst case, when the maximum effort is expended to obtain the clue. If we can obtain the clue with the minimum effort, the difference between the maximum and minimum efforts is calculated as shown in Figure 6.

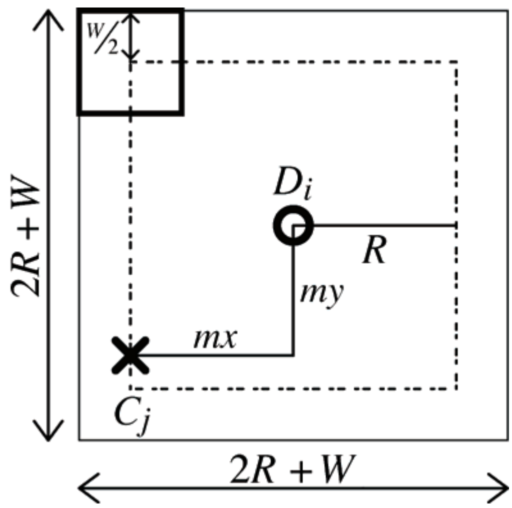


Figure 5. Formulation method of load associated with searching for a clue

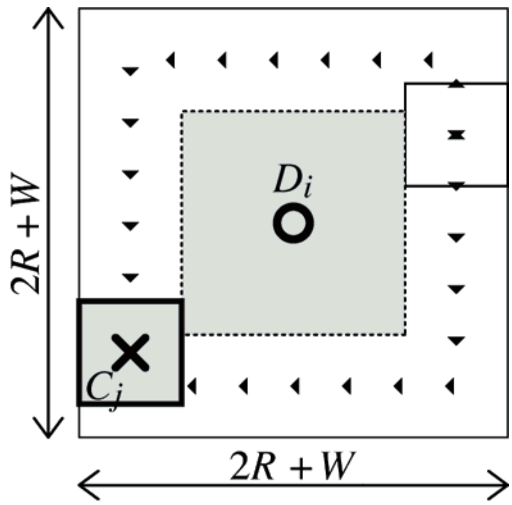
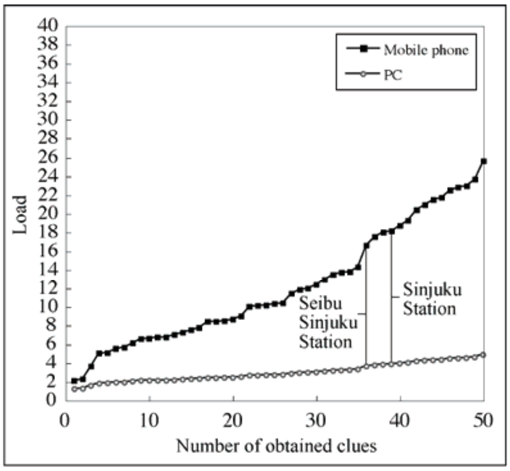


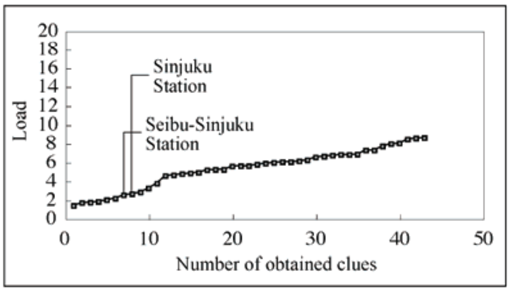
Figure 6. Difference between maximum and minimum efforts (shaded area)

This calculation method is applied to the spatial relationships among destinations D1, D2, and D3, and clues that comprise recognizable buildings in Figure 1. Figure 7 shows the calculation results. In Figures 7-1b, 7-2b, and 7-3b, clues are separated into clues that are recognizable at a scale of 1/8,000 and clues that are recognizable at a scale of 1/1,500. In addition, in order to calculate the inconvenience of reading maps on mobile phones compared with reading maps on PCs, the formulated method is applied to the process of searching for clues using PCs only at a scale of 1/1,500. This is because the viewable area of the PC at a scale of 1/8,000 is far greater than the objective region shown in Figure 1. The viewable area of a PC, the display resolution of which is 1,280 × 1,024 pixels, at a scale of 1/1,500 has a square area of 373 × 373 m^2. Figures 7-1c, 7-2c, and 7-3c are extracted from Figures 7-1b, 7-2b, and 7-3b for comparison with Figures 7-1c, 7-2c, and 7-3c at the same scale. The 1/1,500 scale results (Figures 7-1c, 7-2c, and 7-3c) obtained using a mobile phone suggest that there are more clues than the 1/8,000 scale results (Figures 7-1a, 7-2a, and 7-3a). However, the viewing area of a map at a scale of 1/1,500 is smaller than that at a scale of 1/8,000 (Figure 3). Therefore, if we search for the same clue, e.g., Shinjuku Station, on maps of both scales, the load associated with searching for the clue on the large-scale map is larger than that associated with searching for the clue on the small-scale map. This is caused by the wealth of information available on a large-scale map, which may contain as many as three times the number of clues on a small-scale map (Figure 2). Note that this increase in the number of clues is much smaller than the increase in the total number of, which is 28, that is the squared increasing rate of scale. This indicates that, as the scale is enlarged from 1/8,000 to 1/1,500, the increase in number of recognizable buildings is not as great as the increase in total number of buildings. Thus, using a small-scale map, we obtain fewer clues in the process of finding Shinjuku Station. The curves of the loads of Figures 7-3a and 7-3c are more moderate than other curves because of the interaction among location D3, the distribution pattern of clues near D3, and the calculation method.

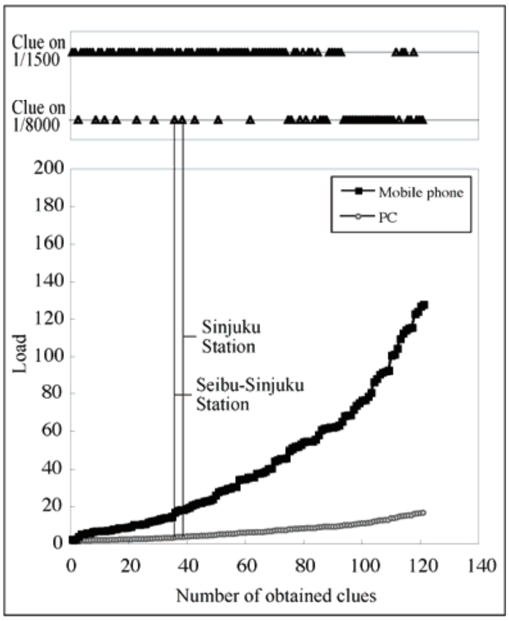
Next, we focus on the differences between the load for a mobile phone and the load for a PC at the scale of 1/1,500. The curves of loads for a PC in Figures 7-1b, 7-2b, and 7-3b are more moderate than the curves of loads for a mobile phone because the viewable area of the PC is approximately 10 times larger than that of the mobile phone. Note that the load for a PC at a scale of 1/1,500 is similar to that for a mobile phone at a scale of 1/8,000, while the number of obtained clues is relatively small, say, around 10 or 20. This can be explained as follows. The visible area of a PC is about 10 times larger than that of a mobile phone. Furthermore, the number of clues included in a window of a fixed device at a scale of 1/1,500 is 1/10 that at a scale of 1/8,000 because the visible area shrinks to 1/28 whereas the number of the clues per unit area increases about three-fold. This implies that the total load for a PC at a scale of 1/1,500 may be slightly larger than that for a mobile phone at a scale of 1/8,000.



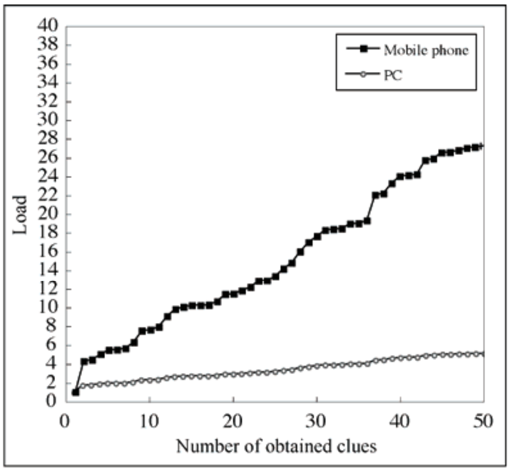
7-1c. D1 (1/1,500 scale, mobole phone and PC)



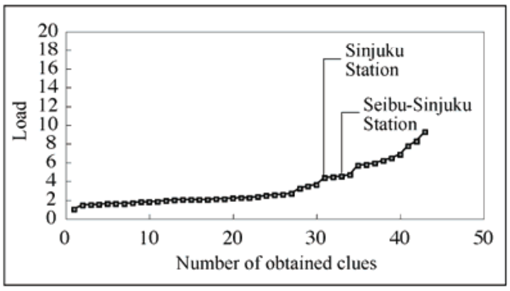
7-1a. D1 (1/8,000 scale, mobole phone)



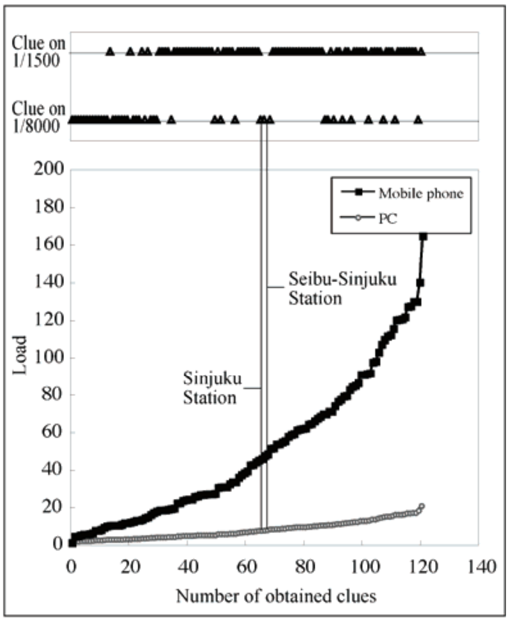
7-1b. D1 (1/1,500 scale, mobole phone and PC)



7-2c. D2 (1/1,500 scale, mobole phone and PC)

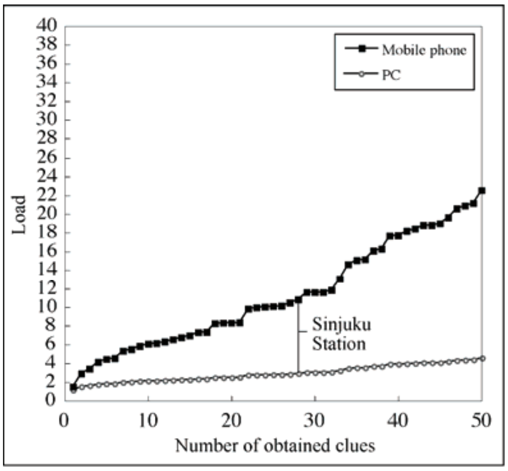


7-2a. D2 (1/8,000 scale, mobole phone)

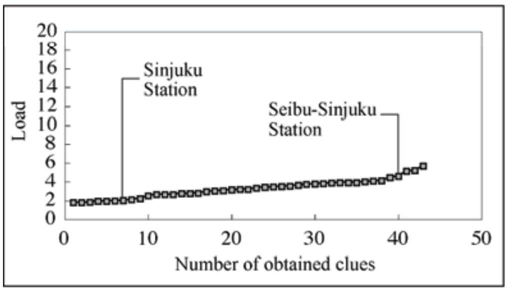


7-2b. D2 (1/1,500 scale, mobole phone and PC)

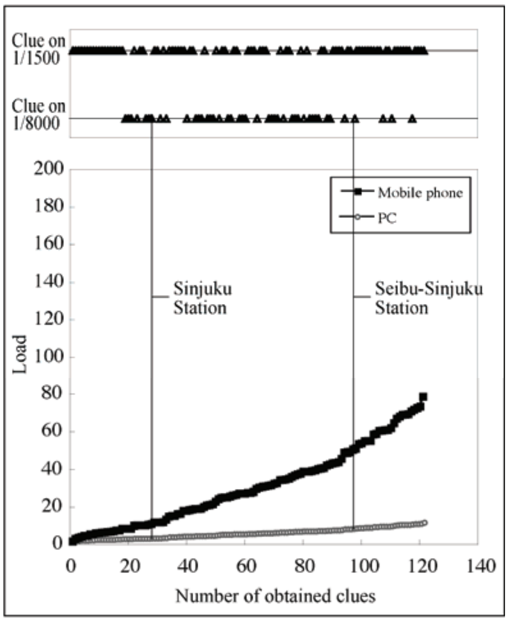
Figure 7 Load associated with searching for clues



7-3c. D3 (1/1,500 scale, mobole phone and PC)



7-3a. D3 (1/8,000 scale, mobole phone)



7-3b. D3 (1/1,500 scale, mobole phone and PC)

Figure 7 Load associated with searching for clues

6. CONCLUDING REMARKS

The present study estimated the readability of maps displayed on mobile phones, focusing on the process of identifying the destination based on clues consisting of geographical information near the destination. The newly developed calculation method will be useful for improving the usability of maps displayed on mobile phones, which have functions similar to PCs. In addition, this method was constructed by combining existing frameworks, including Cross K-function Analysis, which is used to analyze the spatial relation between two different distributions of point-like features, and information seeking behavior, which is often discussed in the intervening opportunity model. Furthermore, this method provides a simple method by which to analyze the essential problem of reading maps of limited size.

The following issues remain to be addressed:

(1) Application of the proposed calculation method to other areas,

(2) Verification of the efficacy of recognizable buildings as clues by which to identify a destination,

(3) Calculation of an optimum relationship between the quantity of displayed clues and their variety on maps for mobile phones, and

(4) Investigation of the information seeking behavior in a relatively large viewable area.

7. ACKNOWLEDGEMENTST

This project was supported by Tokyo Metropolitan University International Research Grant. We would like to thank to the anonymous referees for providing valuable comments.

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